METHOD AND APPARATUS FOR PRESSURE SORE DETECTION

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a continuation-in-part of U.S. patent application Ser. No. 12/875,983, filed on Sep. 3, 2010, entitled "Method and Apparatus for Total Hemoglobin Measurement," which is a continuation-in-part of U.S. patent application Ser. No. 11/381,443, filed on May 3, 2006, entitled "Method and Apparatus for Lymph Node Mapping," both of which are incorporated herein by reference.

FIELD OF THE INVENTION

The field of the present invention pertains generally to optical imaging using near-infrared light, including more specifically, to the optical detection of sentinel lymph node location in order to guide surgical procedures.

BACKGROUND

Sentinel lymph node biopsy is a surgical procedure that involves removing a small sample of lymph tissue and examining it for signs of cancer. As an alternative to conventional full lymph node dissection, it is increasingly used as the standard of care in the staging of breast cancer and melanoma. The sentinel lymph node (SLN) is the first node, or group of nodes, in the lymphatic network to come into contact with metastatic cancer cells that have spread from the primary tumor site. SLN biopsy allows a physician to obtain information about the other lymph nodes in the network without exposing the patient to the risks of conventional surgery. Further surgery to remove other lymph nodes may be avoided if no cancer cells are found in the sentinel lymph nodes.

SLN biopsy usually begins with the injection of a radioactive tracer (technetium-99 sulfur colloid), a blue dye, or both into the area around the original cancer site. Lymphatic vessels carry the tracer to the sentinel node (or nodes); this is the lymph node most likely to contain cancer cells. Prior to surgery, a wide field-of-view gamma camera is typically used to image the location of the radiotracer. Images are generally taken from multiple positions and perspectives, resulting in a map of the drainage pattern of lymphatic fluid from the skin to the lymph nodes. By showing where the cancer is likely to have spread, the map enables the surgeon to plan the full procedure prior to the first incision. During surgery, the surgeon achieves further guidance either through direct visualization of the injected blue dye or by detecting the radioactive tracer with a hand-held gamma probe. After surgery, the lymph node is sent for pathological examination that can include microscopic inspection, tissue culture, or immunological tests.

The current approach of using radioisotopes for SLN mapping has several drawbacks. First, while the radiation risk to patients and medical practitioners is relatively low compared to other medical procedures, the handling of radioisotopes still requires special precautions. Second, the procedure requires the coordination of both surgical and nuclear medicine personnel, resulting in both scheduling issues and increased cost. Lastly, the time required for the radiotracer to travel through the lymphatic system can be as long as several hours. It is highly desirable to have an alternative system that could be used without radiotracers and that a surgeon could

utilize without the involvement of other specialists. It is also desirable to have a system that uses a contrast agent with more rapid kinetics.

Diffuse optical imaging techniques are known in medical and biological applications. Overviews of diffuse optical imaging techniques can be found in "Recent Advances in Diffusion Optical Imaging" by Gibson, et al, Phys. Med. Biology, vol. 50 (2005), R1-R43 and in "Near-infrared Diffuse Optical Tomography," by Hielscher, et al, Disease Markers, Vol. 18 (2002), 313-337. Briefly, diffuse optical imaging involves the use of near-infrared light incident upon a sample of interest. An example in the medical and biological field is optical mammography where near infrared light is used to illuminate breast tissue. A detector is placed on the opposite side of the breast from the incident light some distance away and collects scattered light from the breast tissue. The scattered light of interest that is detected may be directly scattered incident light or scattered fluorescence light caused by the excitation of an injected fluorescing material that fluoresces when exposed to the incident light. By measuring the amplitude of the light of interest at the detector and the distribution of photon arrival times at the detector for various source and detector positions, a reconstruction of the underlying tissue optical properties can be made. An overview of image reconstruction techniques can be found in the citations given in the aforementioned review articles.

Measurements of the photon flight-time distributions are typically carried out using either a time-domain or a frequency-domain technique. In the time-domain technique, the sample is excited with pulse of light from a pulsed laser and the scattered light is measured using a detector with single-photon sensitivity. The detector measures the time delay between the excitation pulse and the first detected photon. The flight-time distribution is determined by using many repeated pulses and building up a histogram of the measured time delays. Unfortunately, the pulsed laser sources and single-photon detectors are relatively expensive. Because detection is typically done at the single-photon level, it can require a significant amount of time to build-up enough data to approximate the flight-time distribution. One disadvantage of the frequency-domain approach is that it is not a direct measurement of the photon flight time. Rather, it provides an estimate of the mean flight time based on the phase shift between a detected signal and the excitation signal. In some cases, more accurate image reconstructions can be obtained using more complete measurements of the flight-time distributions. This data is not readily obtained with frequency-domain instrumentation. A further disadvantage of the frequency-domain approach is the need for accurate high-frequency analog electronics. An overview of both the time-domain and frequency-domain techniques can be found in the above-referenced article by Hielscher, et al.

U.S. Pat. No. 5,565,982 discloses a time-resolved spectroscopy system using digital processing techniques and two low power, continuous wave light sources. The disclosed system requires two light transmitters of different wavelengths modulated with separate codes for interrogating a sample of interest. Properties of the sample are inferred by differential comparison of the return signals from each of the two light sources. It is undesirable to have two distinct light sources due to the cost and complexity involved. Furthermore, the noise level associated with a measurement made with two separate light sources will be higher than with a single source even if the codes used to drive the two sources are orthogonal. It is desirable to have a means of interrogating a particular tissue volume with a single light source at one wavelength in order to obtain temporal information.